



Armed Forces College of Medicine AFCM



Introduction & energy balance

R.Q. & M.R.

By

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

1. Define the following terms (metabolism, anabolism catabolism, energy balance, respiratory quotient & metabolic rate)
2. Analyze energy balance
3. List causes of positive and negative energy balance
4. Enumerate constituents and functions of food
5. Clarify physiological and physical heat values
6. List the factors affecting metabolic rate (M.R)

Metabolism

- *This term refers to all chemical reactions & energy transformations that occur in the body*
- *The metabolic reactions are divided into two types*



1- Anabolic reactions

- Synthesis of big molecules that support growth of new cells and tissue structure & energy storage for use in the future

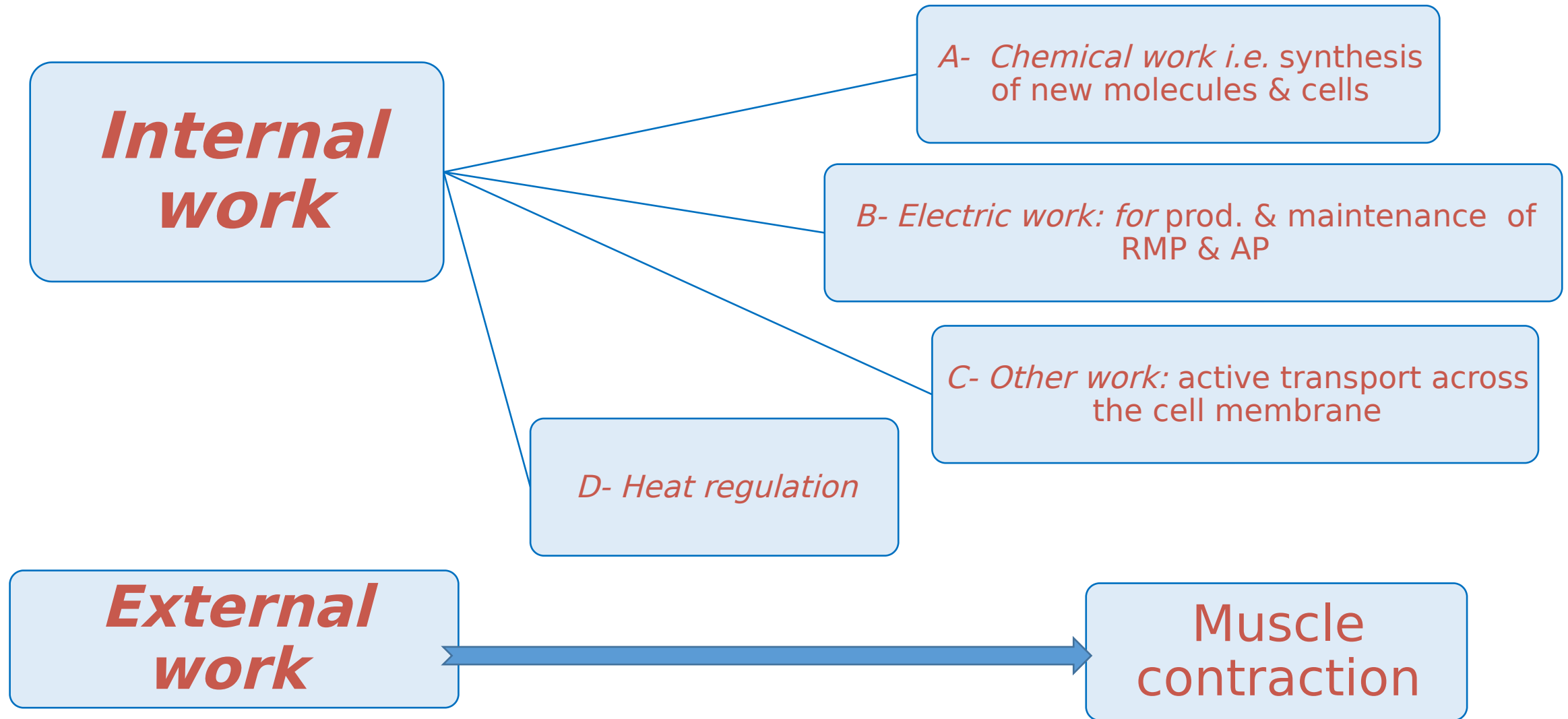
- **It consumes energy**

Both reactions occur in all tissues

2- Catabolic reactions

- Breakdown of big materials via oxidation of food stuffs into small ones with **liberation of energy** that is used for many ????

The energy liberated by catabolic processes in the body used for



Energy Input

- Your energy input is coming from the food that you eat or.....



- Calories coming from our food
- Calories (energy) provided by 3 macronutrients:
 - Fat
 - Carbohydrate
 - Protein
- * A typical mixed meal consists of carbohydrates, proteins and lipids
- * An optimal diet includes, in addition to sufficient water, CHO, protein, fat, minerals and vitamins





A balanced diet is important for health, and certain substances obtained from the diet are essential for life

A- Carbohydrates

($\approx$ for
production of
energy)

B- Fats

($\approx$ for
production of
energy)

C- Proteins

($\approx$ for
building of
new cells)

D- Vitamins & minerals

($\approx$ for
regulation of
metabolic
reactions &
maintenance
of health)

The energy liberated in the body



1- (75 - 80 %) appears as thermal energy (heat)

2- (20-25 %) Stored in the form of organic phosphate compounds (e.g. ATP & CP)

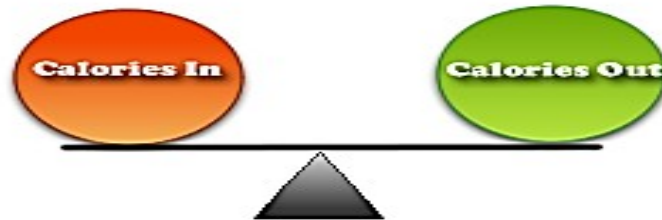
The stored type of energy is converted into

Energy Balance

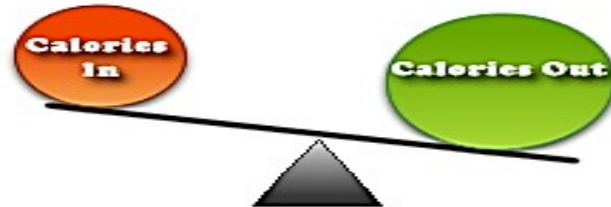
Energy is neither created nor destroyed, it is converted from one form to another



Energy balance



Weight Maintained
Isocaloric Balance
Energy In = Energy Out



Weight Loss
Negative Caloric Balance
Energy In < Energy Out



Weight Gain
Positive Caloric Balance
Energy In > Energy Out

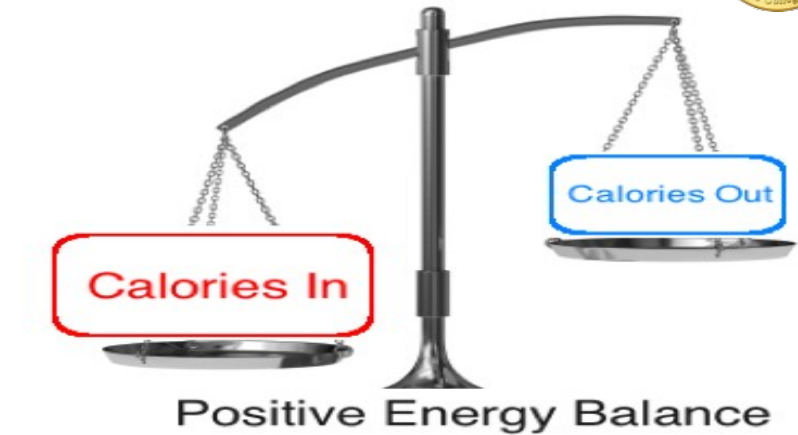
http://cdn.shopify.com/s/files/1/1869/7329/articles/BalCalories2_1024x1024.png?v=1537620861

The caloric value of the dietary intake must be approximately equal to the energy expended if body weight is to be maintained and also for homeostasis

Variation in energy balance



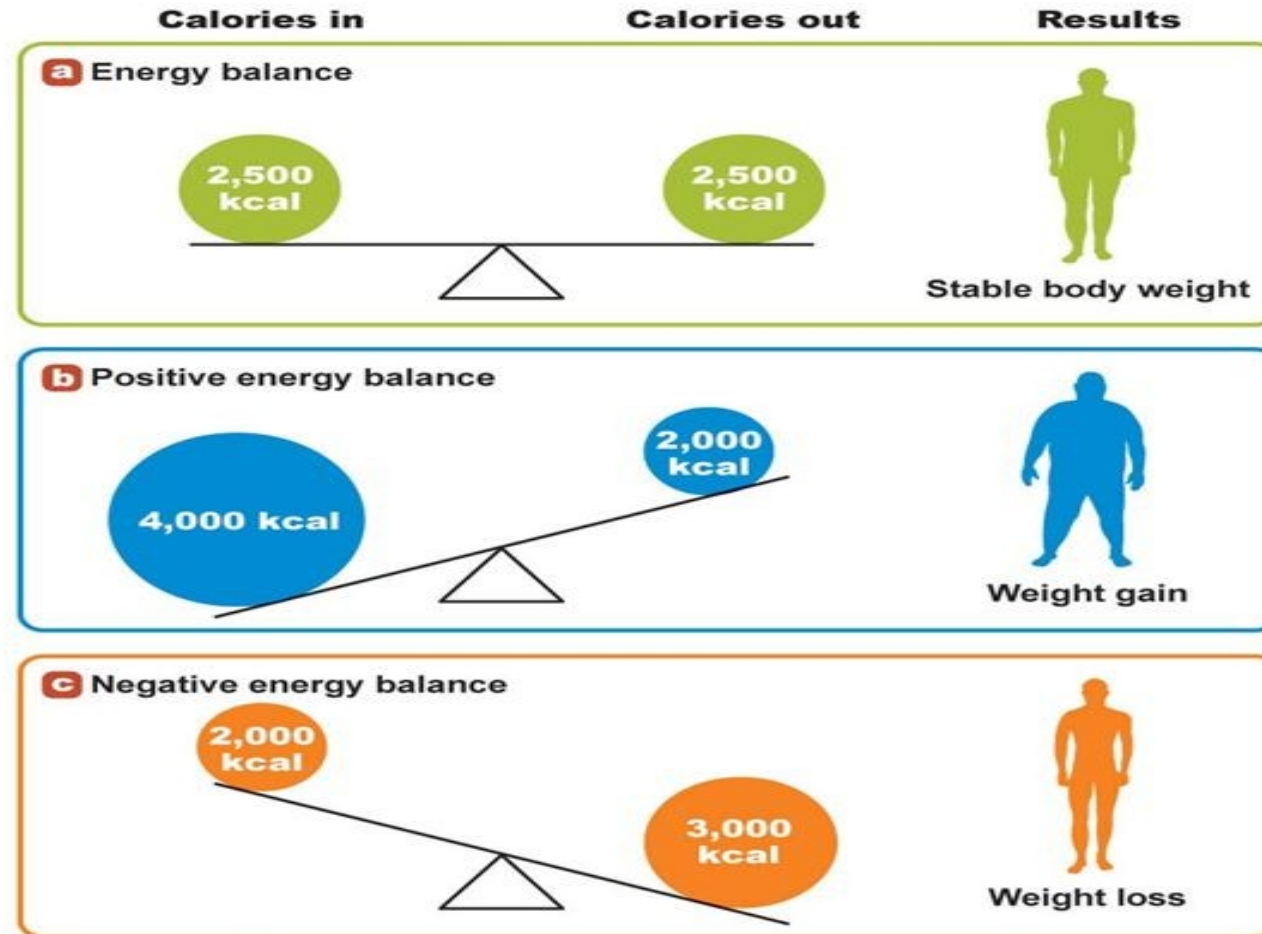
1) **+ ve energy balance** : If energy intake (input) is more than energy output → more anabolism and more energy stores → increase in body weight as in obesity & growth of children



2) **- ve energy balance** : If energy intake is less than energy output → the endogenous energy stores are catabolized more than normal → loss of body weight e.g. under nutrition, starvation and anorexia nervosa



The Concept of Energy Balance



https://images.slideplayer.com/18/6161000/slides/slide_2.jpg

Daily caloric requirements



- The average adult must take in about 2000 kcal/d
- Caloric requirements above the basal level depend on the individual's activity
- The average sedentary student (or professor) needs another 500 kcal, whereas a lumberjack needs up to 3000 additional kcal per day
- In addition to the 2000 kcal/d necessary to meet basal needs, 500 to 2500 kcal/d (or more) are required to meet

Unit of Energy



- The standard unit of heat energy is the calorie (cal)
- **Calorie (cal):** It is the amount of heat energy necessary to raise the temperature of 1 g of water 1 degree, from 15 °C to 16 °C
- **Calorie (cal)**= gram calorie= small calorie= standard calorie
- The unit commonly used in physiology and medicine is the Calorie (kilocalorie; kcal)
Kilocalorie = 1000 calorie



Physical heat value

- Physical heat value: The amount of energy liberated when 1 gram of food substance is completely oxidized outside the body
- Caloric value of food (physical heat value)

CHO -----4.1 KCal/g

Fats-----9.3 KCal/g

Protein-----5.3 KCal/g

Estimation of energy intake

- The amount of energy intake is obtained by multiplying the ingested amount of each type of food in grams X its physiological heat value

???

- e.g. ???

Physiological heat value



The amount of energy liberated by 1 gram of food substance when it is completely oxidized **inside** the body

CHO-----4.0 KCal/g.

Fats-----9.0 KCal/g.

Protein-----4.1 KCal/g.

???????

❖ **N.B.:**

*** The physiological heat value of protein (4.1) is less than its physical heat value (5.3) due to **????** incomplete oxidation of protein inside the body

The metabolism of 10 gm of protein inside the body produce....

- 1) 53 Kcal
- 2) 93 Kcal
- 3) 410Kcal
- 4) 41 Kcal

The metabolism of 10 gm of protein inside the body produce....

1) ≈ 53 Kcal

2) ≈ 93 Kcal

3) ≈ 410 Kcal

4) ≈ 41 Kcal

Respiratory Quotient (RQ)



The respiratory quotient (RQ) is the ratio in the steady state of the volume of CO_2 produced to the volume of O_2 consumed per unit of time

Volume of CO_2 produced

RQ = ----- as a ratio at the
same time

Volume of O_2 consumption

N.B.: It should be distinguished from the respiratory exchange ratio (R)

Importance of RQ



1. Determines the nature of food substance oxidized and utilized in different tissues and under different conditions

RQ of CHO ----- = 1 Why???

RQ of Fat ----- = 0.7

RQ of Protein----- = 0.82

Carbohydrate:
 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (glucose)
 $RQ = 6/6 = 1.00$

This is because H and O are present in carbohydrate in the same proportions as in water, whereas in the various fats, extra O_2 is necessary for the formation of H_2O .

RQ of the brain is regularly 0.97– 0.99, indicating that its principal but not its only fuel is carbohydrate.

2. Indicates the transformation of one food substance to another in the body

CHO (rich in O_2) $\square$ Fat (poor in O_2) $\square$ more CO_2 production $\square$ higher RQ

3. Help in calculating the metabolic rate

4. Negative RQ ???



Metabolic Rate

Def.:- The amount of energy liberated per unit of time

It is better to expressed per square meter surface area

Cal/h/m²

* Most of body energy production appears as heat (thermal

ene The metabolic rate is estimated by the following methods:

• $\approx 20\%$ as stored energy

1-
Direct
calorimetr
y

2-
Indirect
calorimetry

3-
Simplified
indirect
calorimetr
y

Factors affecting MR



Muscular exercise □
Increase the metabolic rate



Pregnancy □ Increase the
MR, Why ?



Sleep □ Decrease the MR
???

Factors affecting MR



Environmental temperature

Exposure to cold $\square$ heat producing mechanisms

Environment cooling $\square$ increase MR

Exposure to hot. $\square$ body temp. $\square$ Metabolic rate $\square$ increase MR about 14% for each Celsius of elevation.

The curve relating the metabolic rate to the environmental temperature is U-shaped.



Factors affecting MR



Age

- ** Max. MR during early life.
- ** Declines with advanced age.



Sex

MR increased in male than in females. Why?

Factors affecting MR



Recent ingestion of food $\square$ Increase the MR.
Why? because of their specific dynamic action
(SDA)..???



Body size (height, weight
and surface area)
Increase body size $\square$
increase MR



Race
Different races- $\square$ different
MR

Factors affecting MR



Emotions $\square$ increase MR by:-

- 1- Increase Ms. Tone
- 2- Epinephrine secretion



Endocrinal factors:-e.g.

- 1- Catecholamines $\square$ $\uparrow$ MR
- 2- Thyroxine $\square$ $\uparrow$ MR

Factors affecting MR



Body temperature
Increase body temp. $\square$
increase MR



MR $\square$
1- decrease sympathetic
activity.
2-decrease thyroid

Summary

Metabolism “Anabolism & Catabolism”

Energy balance “+ve Or -ve”

Food has “Physiological & Physical heat value”

RQ is important

Factors affecting MR may be physiological or pathological



Lecture Quiz



Q1. Which of the following has the greatest effects on a lack of blood glucose?

- a) The brain b) The heart c) The liver

Q2. Which of the following increased the MR maximally?

- a) Exercise b) Specific dynamic action of food c) Hyperthyroidism

Q 3. Which of the following food constituent has physiological heat value less than its physical heat value?

- a) CHO b) Fat c) Protein

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SUGGESTED TEXTBOOKS



1. Ganong's "Review of Medical Physiology", 25th edition, chapter 72, pages 459-467
2. Guyton and Hall "Textbook of Medical Physiology" edition, chapter 72, pages 862-865
3. Sembulingam "Essentials of Medical Physiology", 6th edition, chapter 124 page 710

